Testimony of
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Before the United States Senate
Science, Commerce and Transportation
Subcommittee on Disaster Prevention and Prediction
June 8, 2005

Good afternoon. Mr. Chairman, Ranking Member Nelson, and members of the Subcommittee, thank you very much for the opportunity to present testimony on the National Science Foundation's role in advancing science and engineering's capability to enhance our nation's homeland security.

As you know, when Congress established the National Science Foundation (NSF) in 1950, it gave the agency a broad mission: "to promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense…" As such, much of NSF's activity directly supports our nation's ability to secure the homeland. NSF plays a critical role in underwriting fundamental research, education and infrastructure at colleges, universities and other institutions throughout the country. This effort produces future generations of world-class scientists and engineers who develop ideas and research tools that address the challenges we face today and those we will face in the future.

Research supported by NSF accounts for approximately thirteen percent of federal support for basic research and approximately forty percent of non-life-science basic research at U.S. academic institutions while representing less than four percent of the federal funding for R&D. This work, at the frontiers of knowledge, represents much of our nation's most advanced capability in materials science research, sensors and the architecture of sensor networks, genomics, cyber-security, data mining, and understanding of human and social dynamics, among others. Much of this work has direct impact upon our nation's present and future-generation homeland security systems and capability.

The April 2005 report from the Office of Science and Technology Policy (OSTP), *Science and Technology: A Foundation for Homeland Security,* identifies the following areas where our nation's research communities will play vital roles: 1) Science and Technology For Defense Against Catastrophic Threats and 2) Science and Technology to Counter Terrorism. NSF has supported basic research in these two areas from the Foundation's origins and much of today's capabilities can trace their lineage back to NSF-sponsored fundamental work. Moreover, in response to emerging threats, NSF has increased support for several activities outlined as critical in the OSTP report. What I outline below are some of the activities sponsored by NSF that directly address the topics the OSTP report identifies as critical to advance our nation's science and technology base for supporting homeland security.

The National Science Foundation Research Portfolio:

CBRNE

As a first example, the OSTP report identifies Radiological and Nuclear Countermeasures as a key component to countering the threat of weapons proliferation, and the 2002 National Strategy for Homeland Security states: "Our highest scientific priority must be preventing terrorist use of nuclear weapons." A critical component capability to defend against nuclear proliferation and inhibit border penetration by a nuclear or radiological weapon is the ability to detect the presence of illicit fissile material. To detect such contraband, new sentinel systems and detectors enabled by critical advances in material sciences must be fielded at home and abroad. It is widely believed among the scientific community that nanotechnology will lead the way to the advanced capability in material sciences required to enable these systems. As the lead agency of the National Nanotechnology Initiative (NNI), NSF directed the 2004 restructuring of the NNI in part to accelerate the realization of new nano-structured materials and therefore hasten developments to enhance our ability to detect Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) materials.

The OSTP report also identifies early detection of Biological and Chemical Threat Agents as a critical capability required to enhance our nation's homeland security. The early detection of Biological and Chemical Threats, like the ability to detect fissile material, requires advanced knowledge of material science and sensor engineering. NSF supports both of these activities within and beyond the NNI.

For instance, NSF funds the Materials Research Science and Engineering Centers program. These centers are located at leading academic institutions in seventeen states across the country and represent a significant portion of our nation's most advanced work in the area of material science. NSF also co-funds a program titled: Interaction in Chemistry, Materials Research, Molecular Biosciences, Bioengineering, and Chemical Engineering with the National Institute of Standards and Technology (NIST). This program was developed to facilitate the interaction between NSF-sponsored academic researchers and NIST's Chemical Science and Technology Laboratory and Materials Science and Engineering Laboratory. These laboratories house NIST's activity on chemistry, materials research, molecular biology, bioengineering, and chemical engineering, all relevant to advancing our capability for detecting chemical and biological threats.

Sensors and Sensor Networks

In the area of advanced sensors, NSF's Sensors and Sensor Networks program seeks to advance fundamental knowledge in the engineering of materials, concepts and designs for new sensors, networked sensor systems in a distributed environment and the interpretation and use of sensor data in decision-making processes. Like most of the activity sponsored by NSF, the capabilities enabled represent state-of-the art research at the frontiers of knowledge and comprise a significant proportion of our nation's most advanced work on sensor and sensor systems. This work includes research that investigates networks for health monitoring and damage assessment of the civil infrastructure, both physical and cyber. Flexible and scalable software architectures

and frameworks are being developed to integrate real-time heterogeneous sensor data, database and archiving systems, computer vision, data analysis and interpretation, numerical simulation of complex structural systems, visualization, probabilistic risk analysis, and rational statistical decision making procedures.

To highlight some of this advanced activity, NSF sponsored a media briefing last September titled "Sensors: Buildings, Battlefields, and Beyond" which described what many of our nation's top technology leaders believe is the next generation of the information technology revolution, namely the ability to augment our advanced computational resources with a wide array of geographically-distributed sensor data. Clearly, this focus on sensor and sensor networks will have impact in the area of homeland security.

The OSTP report also identifies Medical Countermeasures to Weapons of Mass Destruction (WMD) as a critical capability where our Science and Technology community can contribute. While most of our nation's work in this area is supported by the Department of Health and Human Services, NSF has and will continue to play a significant role. NSF, in collaboration with the Department of Agriculture, has funded a program on microbial genome sequencing that provides key information enabling identification and understanding of the life functions and ecology of microbes, some of which have the potential to be used in biological-based WMD. The genome sequence of these microbes, once known, can be utilized to develop countermeasures such as antimicrobial chemicals and vaccines. This jointly funded program also relates directly to protecting our agricultural systems from both man-made and naturally occurring threats, also identified in the OSTP report as a critical initiative.

Agriculture

Protecting agriculture and our food supply represents a unique area where a synthesis of NSF activity contributes to our nation's homeland security. As stated above, NSF co-sponsors research into microbial gene sequencing and sponsors sensor and sensor networks, both of which are directly related to securing our agricultural supply chain. NSF also supports the Biochemical Engineering and Biotechnology program which funds technology development for the purpose of monitoring and controlling bioprocesses and food processing with a special focus on the safety of the nation's food supply.

Another area of activity that NSF supports is the Environmental Engineering and Technology program. This program focuses on research with the goal of reducing adverse effects of solid, liquid, and gaseous discharges into land, fresh and ocean waters, and air as a result of human activity. This program also supports research on innovative biological, chemical, and physical processes used alone or as components of engineered systems to restore the usefulness of polluted land, water, and air resources. The understanding of these engineered systems will lead to advanced national capabilities in the area of remediation, an area directly related to homeland security.

The OSTP report identifies Biometric Identification as a critical need and has created the National Science and Technology Council's subcommittee on biometrics. NSF is represented on this subcommittee and also sponsors advanced research at the Center for Identification

Technology Research as well as numerous grants to the small business community that advance state-of-the art biometric capability in a commercial setting.

First Responders

To enhance first responder capability, NSF has sponsored work in advanced ad-hoc networking to enable the rapid deployment of communications networks. Along with the Department of Defense, NSF has sponsored the Center for Robot Assisted Search and Rescue. To advance the first-responders capacity to deal with chemical and biological threats, NSF has sponsored work that led to the development of an advanced material nano-engineered to quickly absorb and destroy a wide array of toxic chemicals. The commercial development of this material also is being sponsored by an NSF Small Business Innovation Research (SBIR) grant. This is one example where original fundamental NSF-supported academic research and the subsequent support from the NSF SBIR program has directly led to a potentially significant advance in the area of homeland security. The small business concern is currently working with the Environmental Protection Agency to develop capability for water remediation.

Information Technology

Another critical area that pertains to homeland security where NSF is actively supporting our nation's capabilities is in the area of Information Technology. Specifically NSF, in collaboration with the Department of Homeland Security, supports the Cyber Defense Technology Experimental Research network, a collaborative network developed as a testbed for cyber war gaming. NSF also supports the Center for Internet Epidemiology and Defenses, which is dedicated to wiping out worms and viruses that infect thousands of computers and cause billions of dollars in damage. These two centers represent just a small fraction of the Information Technology Research NSF supports that is directly relevant to homeland security.

Computers, especially those that are networked, reside at the heart of systems on which people now rely, both in critical national infrastructures and in their homes, cars, and offices. Today, many of these systems are far too vulnerable to cyber attacks that can inhibit their function, corrupt important data, or expose private information.

To respond to these challenges, NSF established a new program in FY 2004 called Cyber Trust to complement ongoing cybersecurity research and education investments made in the core Computer and Information Science and Engineering programs. The Cyber Trust program promotes a vision of a society in which networked computer systems are more predictable, more accountable, and less vulnerable to attack and abuse. It also foresees systems that are developed, configured, operated and evaluated by a well-trained and diverse workforce and used by a public educated in their secure and ethical operation. As such, the program covers a wide range of research areas. In FY 2006, focused investments in this area will be both in foundation establishment and security-measure development. The former is important since we will only be able to develop predictably trustworthy computer systems if we can model and analyze cyber-trust-related phenomena. Given security threats faced today, we also need to accelerate developing technologies that can immediately address these threats.

I would note that we chose the title "Cyber Trust" because our understanding is that the public not only wants their information systems to be secure, but that they want to *trust* them in all kinds of situations. As a simple example, they need to be able to trust that data will be kept private.

In the area of cybersecurity, NSF announced in mid-April our intention to establish two new Science and Technology Centers (STCs) in fiscal 2005 – one a major collaborative cybersecurity project led by the University of California, Berkeley. This new cybersecurity center will investigate key issues of computer trustworthiness in an era of increasing attacks at all levels on computer systems and information-based technologies. The Team for Research in Ubiquitous Secure Technology (TRUST) will address a parallel and accelerating trend of the past decade--the integration of computing and communication across critical infrastructures in areas such as finance, energy distribution, telecommunications and transportation. The center will merge these efforts with investigations of social science questions involving economics, public policy and societal challenges, human-computer interfaces and privacy, among other issues.

NSF also supports a significant amount of work in the area of data mining and the Intelligence Community has provided supplemental funds to further NSF-sponsored research within this area. For example, novel data mining-based anomaly detection techniques developed under NSF support have been incorporated in the Minnesota Intrusion Detection System (MINDS) that help cybersecurity analysts detect intrusions and other undesirable activity in real life networks. MINDS is being used at the Army Research Laboratory Center for Intrusion Monitoring and Protection and at the University of Minnesota to successfully detect novel intrusions, policy violations, and insider abuse that cannot be identified by widely used signature-based tools. MINDS allows cybersecurity experts to quickly analyze massive amounts of network traffic, as they only need to evaluate the most anomalous connections identified by the system. Further summarization of these anomalous connections using association pattern analysis helps in understanding the nature of cyber attacks, as well as in creating new signatures for use in intrusion detection systems. The underlying techniques have applicability in many areas beyond cybersecurity, such as financial and health care fraud detection.

In addition, NSF has and continues to sponsor research in the following areas related to cyber-security: a) security of next generation operating systems, b) forensic and law enforcement foundations, c) human computer interfaces for security functions, d) theoretical foundations and mechanisms for privacy, security and trust, e) improved ability to certify system security properties, f) more effective system monitoring, anomaly detection attack recognition and defense, and g) integrating hardware and software for security.

The Federal Cyber Service Scholarship for Service (SFS) is a program co-sponsored by NSF and DHS that seeks to increase the number of qualified students entering the fields of information assurance and computer security. The SFS program provides scholarship money for a maximum of two years to outstanding cybersecurity undergraduate and graduate students in exchange for an equal amount of time spent in federal government service after graduation. The SFS has supported students who have gone on to either internships or post-graduation

employment within, among others, the following agencies: CIA, DoD (Defense Computer Forensics Lab, NSA), DoE, DHS, DOJ (FBI, CIO), NSF and NASA.

Social, Behavioral, & Economic Sciences

The OSTP report, as well as the recently released report by the National Science and Technology Council, *Combating Terrorism: Research Priorities in the Social, Behavioral, and Economic Sciences,* identifies research on cultural and sociological factors that may give rise to an environment conducive to terrorism as well as research into individual behavioral indicators that may correlate with intent to harm as important areas of study for the science and technology community. In this connection, NSF grants have enabled the sophisticated incorporation of geographic and other spatial data into analyses of human behavior, they have advanced our understanding of how networks link people and organizations, and have supported surveys on religious and democratic values in Islamic and third world countries.

In order to better understand the complex dynamics within and among human and social systems and their environments, NSF has recently initiated a five-year, agency-wide research program in human and social dynamics. Emerging research and tools will provide a window into the human mind that will revolutionize the study of human development and cognition, as well as information processing and decision-making by groups and individuals. Areas critical to homeland security include agents of change, ranging from extremist ideologies to modern technology; the dynamics of human behavior, which includes such topics as effective human-machine interfacing, and decision-making and risk, which has special relevance to preventing, communicating about and recovering from the destructive consequences of extreme events.

The Intelligence Community and NSF are also sponsoring research on the detection of deception that includes investigation and development of behavioral biometrics (measurable behavior traits acquired over time), content analysis in foreign documents and speech, alternatives to the polygraph, and improvements in intelligence analysis by increasing our understanding of thought processes, learning, and decision-making in individuals and teams. Recently, NSF initiated a five-year research program in human and social dynamics. Emerging research and tools will provide a window into the human mind that will revolutionize the study of human development and cognition, as well as information processing and decision-making by groups and individuals. Areas critical to homeland security include agents of change, ranging from extremist ideologies to modern technology; the dynamics of human behavior; and decision-making and risk, which has special relevance to extreme events.

Fielding Advanced Capabilities

In addition to the programs outlined above which *directly* support the OSTP-identified areas of vital Science and Technology for securing our homeland, NSF is supporting research at the frontiers for fielding advanced capability for future-generation needs. Some of this work is supported by the Foundation's SBIR/STTR program that, in accordance with the FY05 Interagency Research and Development Priorities announced by the Directors of OSTP and the Office of Management and Budget, created a cross-disciplinary program to address specific opportunities for developing Security Technologies. The SBIR/STTR Security Technologies

subtopics were developed in collaboration with the DoD, DHS and the Intelligence Community. With this program, NSF only supports leading edge Security Technologies enabled by the convergence of two of the following three technologies: nanotechnology, biotechnology and information technology. The capabilities envisioned by the convergence of these technologies are considered to be among the most profound in human history and NSF believes that the advancements supported by this effort will lead to capabilities in the years and decades to come.

Conclusion

Mr. Chairman, as you can see from the numerous examples above, the National Science Foundation is committed to the advancement of studies that have a direct impact on our nation's homeland security. Our dedicated program staff understands the significance that science and engineering have on security and works to ensure that capabilities at the frontiers of science and engineering today will keep pace with the advances and threats of tomorrow. By supporting work that advances the nation's health, prosperity and welfare, NSF is instrumental in influencing the future of scientific endeavor. NSF works in collaboration with DHS, the Intelligence Community, DoD, DoE, our federal labs and the private sector to ensure that this wealth of knowledge is effectively transferred into capabilities critical for advancement in many areas, including homeland security. The National Science Foundation will continue to participate in a multidisciplinary approach to the challenges faced by the engineering and scientific community in a way that will impact our country for generations to come.

Mr. Chairman, thank you again for this opportunity to testify on a topic of great importance. I hope that I have conveyed the serious approach that NSF has taken to address these issues. I would be pleased to answer any questions you might have.